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FORCES ON A SABOT IN THE GUN BORE--A COMPUTER-AIDED DESIGN TOOL

N. Pudliener, et al

Picatinny Arsenal
Dover, New Jersey

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E. BARRIERES

MARCH 1975

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PICATINNY ARSENAL
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a computer program which computes the static loads and moments on a sabot segment while under the in-bore environment. The physical characteristics of the sabot segments are also computed. Additionally, from the input data, a tape is prepared by the CDC 6500 computer for drawing sabot cross sections on the CALCOMP 570 Digital Plotter, together with a NANCY Digital Printer Plot. The program is intended as another tool in the Computer Aided Design - Engineer (CAD-E) armory.

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INTRODUCTION

The program described in this report is intended as a design aid to give the engineer a tool to establish the static loads and moments on a sabot segment while under the in-bore environment. The physical characteristics of the sabot segments are also computed. Additionally, from the input data, a tape is prepared by the CDC 6500 computer for drawing sabot cross sections on the CALCOMP 570 digital plotter, together with a NANCY digital printer plot.

The computation scheme is capable of handling multiple components of differing densities, but the forces and moments are treated as though the entire sabot is a single rigid body. The user must describe the cross section of the segment, and predetermine the manner in which the pressure is distributed over the surface of the sabot. Also, the weight and first moments are computed utilizing signed (+ & -) densities to describe the geometry. The geometry must be a body of revolution.

GENERAL INSTRUCTIONS

This sabot program, written in Fortran IV, consists of two separate sub-programs, each having its own input. The first sub-program, occurring in the program listing, computes overturning force moments on the sabot as a function of propellant pressure acting on external sabot surfaces, such as the sabot base and loading of rear support and obturation ring, etc. The remaining sub-program computes overturning moments as a sole function of propellant pressure acting between internal sabot parting surfaces.

Instructions pertaining to each of these sub-programs are given in succeeding paragraphs.

With regard to the first sub-program, a physical description is accomplished by dividing the cross section of the sabot into elements, each element being originated at an inflection point in the geometry. Each component is broken down separately into these elements, which are entered as data in x and y coordinates in an ordered sequence following the contour of the components in a clockwise direction.[1] The order is significant to maintain a system to ascertain the direction of the pressure force vector. It is also necessary to introduce signed densities to distinguish a "forward surface" and a "rear surface". A zero density "end point" for components is also

[1]This portion of the program was written to accept a maximum of 75 sets of coordinates.

used to delineate separate components. An example of a two-component sabot divided into elements is shown in Figure 2, page 22. The data are shown in tabular form on page 3. Note that the concept of the negative density is associated with a "rear surface," and that each surface is described in the element number which originates that surface.

The clockwise flow of data refers to the overall direction around the component and not the direction of a point tracing an individual line; points 17 through 28 are ordered by the overall direction around the sabot body, though the surface is curved, such that a point tracing the curve progresses in a clockwise direction. The final end point is entered separately, and should be the same as the first point of the final component in order to establish a closed figure. This separate entry serves the same purpose as the artificial "zero density" points entered within the body of the data.

A moment center is also entered with x and y coordinates. This point is chosen as the point of restraining force, usually located on the projectile. This moment center is the "hinge point" of a segmented ring-type sabot. Since this point will offset the results of the moment balance, it must be chosen with care in order to accurately represent the actual conditions. Also, it should be noted that this moment center is a single point on a three-dimensional figure. Care must be exercised to allow for curvature in selection of the moment center. In some geometrical construction the rotation may occur about a shifting line of multiple points.

A radius, with the x and y coordinates of the radius center, is included for segments which are curved following the inflection point. These values are entered as zeros for straight line segments. The next data item is the density, entered as positive for a forward surface and negative for a rear surface (a rear surface faces the X = 0 coordinate). The next two entries describe the pressure field to which the surface following the inflection point is exposed. The first of these (PV) is a factor by which the chamber pressure (entered later) will be multiplied to give the pressure to which the surface is exposed (usually 1.0 or 0.0). The second code (LP) chooses two options in depicting the pressure distribution on the surface. A code of 1 denotes a constant pressure equal to the chamber pressure times the pressure factor. A code of 2 will distribute the pressure in a linear manner between the pressure given by this entry and the pressure given for the next point.

N	X	Y	R	XR	YR	Density	PV	LP
1.	0.0000	.6670	0.0000	0.0000	0.0000	-.1010	1.	1
2	0.0000	.8290	0.0000	0.0000	0.0000	-.1010	1.	1
3	1.0070	1.0150	0.0000	0.0000	0.0000	-.1010	1.	1
4	1.0070	1.4200	0.0000	0.0000	0.0000	-.1010	1.	1
5	0.0000	1.6880	0.0000	0.0000	0.0000	-.1010	1.	1
6	0.0000	1.9700	0.0000	0.0000	0.0000	-.1010	1.	1
7	.6220	2.0500	0.0000	0.0000	0.0000	-.1010	1.	1
8	.9700	2.0500	0.0000	0.0000	0.0000	.1010	1.	1
9	.9700	1.8760	0.0000	0.0000	0.0000	0.0000	1.	1
10	1.0000	1.8760	0.0000	0.0000	0.0000	-.0470	0.	1
11	1.0000	2.1000	0.0000	0.0000	0.0000	-.0470	0.	1
12	1.7350	2.1000	0.0000	0.0000	0.0000	.0470	0.	1
13	1.7350	1.8760	0.0000	0.0000	0.0000	.0470	0.	1
14	1.0000	1.8760	0.0000	0.0000	0.0000	0.0000	0.	1
15	.9700	1.8760	0.0000	0.0000	0.0000	.1010	1.	2
16	1.7350	1.8760	0.0000	0.0000	0.0000	-.1010	0.	1
17	1.7350	2.0500	0.0000	0.0000	0.0000	.1010	0.	1
18	2.3780	2.0500	0.0000	0.0000	0.0000	.1010	0.	1
19	2.3780	1.9000	.3100	2.3780	1.5900	.1010	0.	1
20	2.0680	1.5900	.3100	2.3780	1.5900	.1010	0.	1
21	2.3780	1.2800	0.0000	0.0000	0.0000	.1010	0.	1
22	5.7000	1.2800	3.0000	5.7000	4.2800	-.1010	0.	1
23	7.5740	2.0500	0.0000	0.0000	0.0000	.1010	0.	1
24	8.3240	2.0500	0.0000	0.0000	0.0000	.1010	0.	1
25	8.3240	1.6500	0.0000	0.0000	0.0000	.1010	0.	1
26	7.7800	1.6500	0.0000	0.0000	0.0000	.1010	0.	1
27	6.2850	.8010	0.0000	0.0000	0.0000	.1010	0.	1
28	6.2850	.6670	0.0000	0.0000	0.0000	.1010	0.	1

There must be one card for each inflection point in this portion of the deck. The next set of two cards enters the moment centers and the end points on one card and the number of segments, the chamber pressure (psi), the spin (rev/sec), a code to determine the output, and up to 60 characters of notes or descriptive information to be included in the printout. An output code of "0" will print all data points, "1" will print the input and pressure distribution, "2" will print only the forces and moments. These last two cards must appear as a set for each run to be conducted.

The following paragraph pertains to input instructions for the final portion of this program. A physical description of the internal gas-pressurized area (defined by obturation zones) between sabot parting surfaces is accomplished in a manner similar to that described above. The bounded planar area is broken down into elements, each element being originated at an inflection point in the geometry. Each element is entered as data in S and T coordinates in an ordered sequence following the boundary of the gas-pressurized area.[2] The final end point is the same as the first point entered to complete the closed figure. Therefore, no separate entry is needed for the end point. There is no moment center entry, as the one entered in X and Y coordinates in the first portion of this program is used.

Data organization of batch processing a job requires a data card deck in a format similar to that shown on Figure 3, page 23. Multiple runs are possible on the same configuration. For instance, several sets of ballistic conditions may be run, or the moment center may be varied, or both of these may be combined. The initial card initiates reading by giving the number of runs and the number of inflection points in the main data. This is followed by the data cards which describe the cross sectional geometry by giving the X and Y coordinates of each inflection point. This, in turn, is followed by data cards which describe the planar area geometry by giving the S and T coordinates of each inflection point. Finally, a set of two cards is provided for each of the respective program runs. These cards give moment centers and descriptive text. An example of data cards giving four program runs is shown in Sample Case Figure 3 on page 23.

[2]This portion of the program was written to accept a maximum of 20 sets of coordinates.

SCOPE CONTROL CARDS USED IN THIS PROGRAM

The following control cards are used to call NANCY print plot and CALCOMP plot subroutines from permanent files stored in Picatinny Arsenal's CDC 6600 system (Ref 1, 2 and 3):

Job, . . .
.
.
.
Request. Tape 77, NT, S. Plotape - your name
Attach (NAN, NANCY, CY=2, SD=16, MR=1, ID=RANDERS)
Load (NAN)
LGO (Your program)

NANCY is a Fortran deck which writes a printer plot on Tape 6 and a CALCOMP plot on Tape 77. The plot routines (Ref 1) also require that OUTPUT be included on the program card. Memory required to load is about 20,000 (octal) CM cells.

INPUT DATA CARDS

1st Card: Header card (only fixed point entries on this card)

Column 1, number of computer runs

Columns 2 and 3, number of "inflection points" about cross section

Columns 4 and 5, number of "inflection points" about pressurized plane area of sabot parting planes.

2nd Group: Elements of sabot cross section (floating point except for Column 40 fixed point entry)

Columns 1-6, X coordinate of cross section

Columns 7-12, Y coordinate of cross section

Columns 13-18, length of radius of curvature

Columns 19-24, X coordinate of radius of curvature origin

Columns 25-30, Y coordinate of radius of curvature origin

Columns 31-36, density

Columns 37-39, pressure

Column 40, pressure code

3rd Group: Elements of pressurized planar surface on sabot parting planes (floating point entries)

Columns 1-6, S coordinate of planar surface element

Columns 7-12, T coordinate of planar surface element

Columns 13-18, radius of curvature magnitude

Columns 19-24, S coordinate of radius of curvature origin

Columns 25-30, T coordinate of radius of curvature origin

4th Card: Sabot segment moment center and end points for cross section (floating point entries)

Columns 1-6, X coordinate of moment center

Columns 7-12, Y coordinate of moment center

Columns 13-18, X coordinate of end point

Columns 19-24, Y coordinate of end point

5th Card: Sabot data input and data callout (floating point except for Column 21 fixed point entry)

Columns 1-2, number of sabot segments

Columns 3-8, propellant pressure (psi)

Columns 9-12, diameter of saboted round (mm)

Columns 13-16, weight of subprojectile (lb)

Columns 17-20, spin of round (rev/sec)

Column 21, If "0" prints all data points

If "1" prints input and pressure distribution

If "2" prints only forces and moments

Columns 22-71, Data statement such as, "sabot test for moment about front edge"

EQUATIONS

The following equations are used in this program:

The area of the trapezoidal element a, b, c, d (Fig 1) is:

$$\text{AREA} = \tfrac{1}{2}\,[2Y_{(n)} \sin (D\beta) + 2Y_{(n+1)} \sin (D\beta)] \times \left[|Y_{(n)} - Y_{(n+1)}|^2 + |X_{(n)} - X_{(n+1)}|^2 \right]^{\frac{1}{2}}$$

The centroid location in the x-direction of the trapezoidal element (Fig 1) is:

$$\text{XCENT} = [X_{(n)} - X_{(n+1)}] \times [2Y_{(n)} \sin (D\beta) + 4Y_{(n+1)} \sin (D\beta)] / 3[2Y_{(n)} \sin (D\beta) + 2Y_{(n+1)} \sin (D\beta)] + X_{(n+1)}$$

for case of $Y_{(n)} > Y_{(n+1)}$

The weight of the prism element formed by the "AREA" multiplied by the rectangle element e, f, g, h (Fig 1) is

$$\text{WT} = \rho \times \text{AREA} \times \cos \left[\text{arc tan } \left| \frac{Y_{(n)} - Y_{(n+1)}}{X_{(n)} - X_{(n+1)}} \right| \right] \times (\text{XCENT})$$

ρ is density

The pressure forces acting on the trapezoidal element (Fig 1), along X and Y directions, are

$$F_x = \text{AREA} \times \text{PS} \times \cos \Theta$$

$$F_y = \text{AREA} \times \text{PS} \times \sin \Theta$$

PS is pressure vector.

IDENTIFICATION OF SYMBOLS

BETAR	Angle in radians between parting sabot planes
N	Number of inflection points about sabot cross section
NJAY	End inflection point around sabot cross section to close loop
NN	Number of inflection points about pressurized zone of sabot parting surface
NNJAY	End inflection point around pressurized zone of sabot planar parting surface
NRUN	Number of computer runs
P(K)	Pressure factor
XCENT	Centroid in X-direction
X(K,J)	X coordinates for inflection points about sabot cross section
S(K,J)	S coordinate for inflection points about pressurized zone on parting planes
THETA(K,J)	Angle between the horizontal and any pressure vector
T(K,J)	T coordinates for inflection points about pressurized zone on parting planes
YCENT	Centroid in Y direction
Y(K,J)	Y coordinates for inflection points about sabot cross section
YVAR	Dummy integration variable

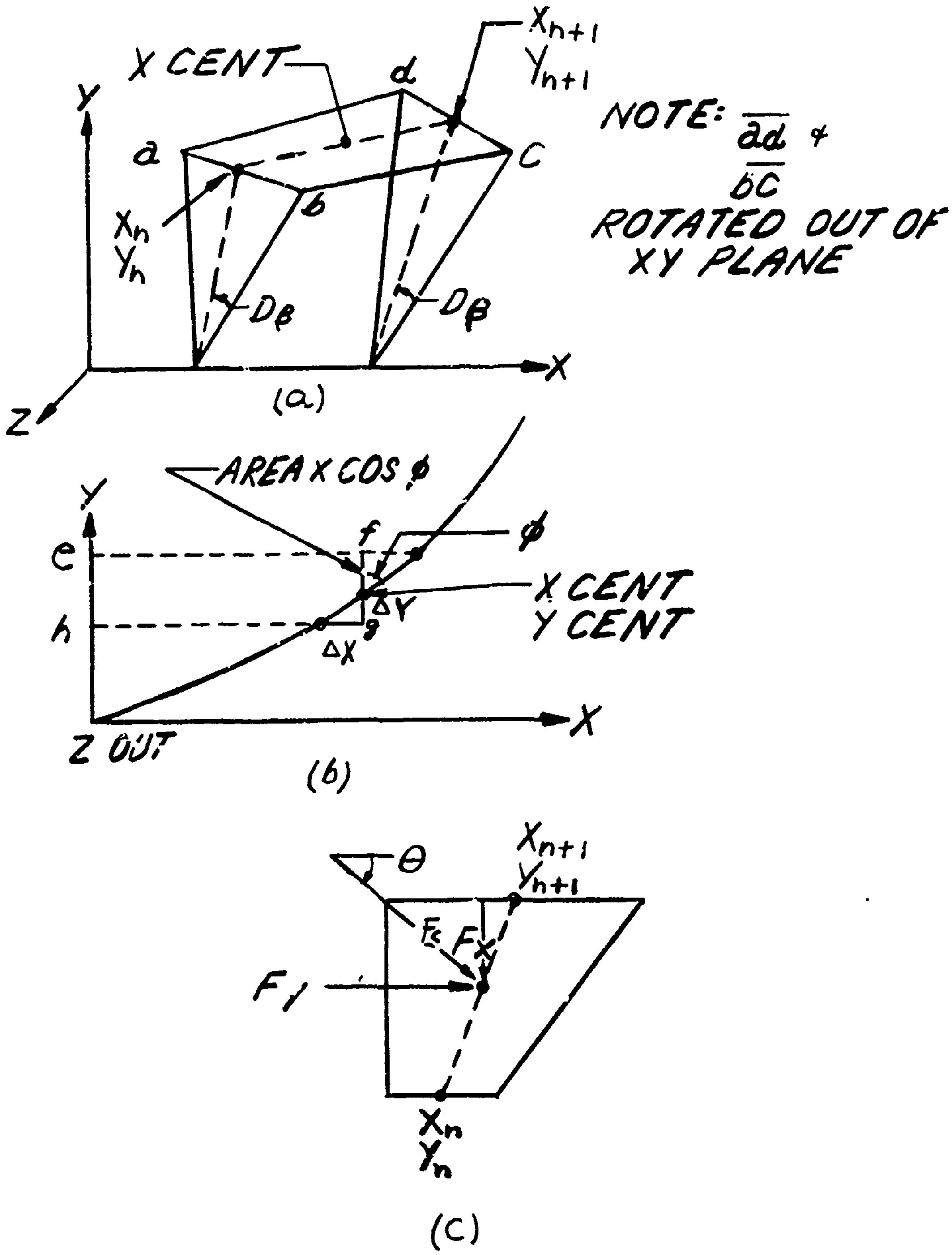

Fig 1 Geometry of Sabot Cross Section

F O R T R A N   L I S T I N G

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```
      PROGRAM NORM(INPUT,OUTPUT,TAPE 5=INPUT,TAPE 6=OUTPUT)
C     PROGRAM(UPDATED BY N. PUDLIENER) ACCOUNTS FOR PRESSURE FORCES
C     AND MOMENTS INDUCED ON THE SABOT INTERFACES AND PROVIDES
C    CONCURRENTLY A NANCY PRINT PLOT AND CAL-COMP PLOT OF THE
C    SABOT CROSS-SECTION.
      DIMENSION X(75,11),Y(75,11),THETA(75,11),PV(75)
      DIMENSION S(20,11),T(20,11)
      DIMENSION ST(200),TT(200)
      DIMENSION STHETA(20,10)
      DIMENSION DATA(7),LP(75),RHO(75),TYPE(6)
      DIMENSION XR(75),YR(75),P(75),R(75)
      DIMENSION XT(750),YT(750)
      DIMENSION RR(20),SR(20),TR(20)
      KRUN=0
      READ(5,1)NRUN,N,NN
    1 FORMAT(I1,2I2)
      NJAY=N*10+1
      NNJAY=NN*10+1
      DO 3 K=1,N
    3 READ(5,2)X(K,1),Y(K,1),R(K),XR(K),YR(K),RHO(K),PV(K),LP(K)
    2 FORMAT(6F6.0,F3.0,I1)
      IF(NN.EQ.0)GO TO 41
      DO 60  K=1,NN
   60 READ(5,61) S(K,1),T(K,1),RR(K),SR(K),TR(K)
   61 FORMAT(5F6.0)
   41 READ(5,4)XLEG,YLEG,XEND,YEND
    4 FORMAT(4F6.0)
      READ(5,55)SEGN,PRE,DIA,WTR,SPIN,KPRINT,(TYPE(J),J=1,6)
   55 FORMAT(F2.0,F6.0,3F4.0,I1,6A10)
      DO 11 K=1,N
      M=K+1
      Y1=Y(M,1)
      Y2=Y(K,1)
      X1=X(M,1)
      X2=X(K,1)
      IF(K.EQ.N)Y1=YEND
      IF(K.EQ.N)X1=XEND
      P(K)=PRE*PV(K)
      IF(R(K))20,18,20
   18 DELY=Y1-Y2
      DELX=X1-X2
      B=ATAN2(DELY,DELX)
      DX=DELX/10.0
      DY=DELY/10.0
      DO 12 J=2,10
      A=J-1
      X(K,J)=X(K,1)+A*DX
   12 Y(K,J)=Y(K,1)+A*DY
      DO 13 I=1,10
   13 THETA(K,I)=B-3.14159/2.
      GO TO 11
   20 DRX=X2-XR(K)
      IF(DRX.EQ.0.)DRX=X1-XR(K)
      KOMP=0
      THETA(K,1)=ATAN2((Y2-YR(K)),(X2-XR(K)))
      THETA(M,1)=ATAN2((Y1-YR(K)),(X1-XR(K)))
      IF(DRX.LT.0.0.AND.RHO(K).LT.0.0)KOMP=1
```

```
      IF(DRX.GT.0.0.AND.RHO(K).GT.0.0)KOMP=1
      IF(KOMP.EQ.1)THETA(K,1)=THETA(K,1)-3.14159
      IF(KOMP.EQ.1)THETA(M,1)=THETA(M,1)-3.14159
      IF(THETA(K,1).LT.0.)THETA(K,1)=THETA(K,1)+6.28318
      IF(THETA(M,1).LT.0.)THETA(M,1)=THETA(M,1)+6.2832
      IF(THETA(K,1).GT.3.14159.AND.THETA(M,1).EQ.0.)THETA(M,1)=6.2832
      DT=(THETA(M,1)-THETA(K,1))/10
      DO 14 J=2,10
      A=J-1
      THETA(K,J)=THETA(K,1)+A*DT
      TTT=THETA(K,J)
      IF(KOMP.EQ.1)TTT=TTT+3.14159
      B=COS(TTT)
      C=SIN(TTT)
      X(K,J)=R(K)*B+XR(K)
      Y(K,J)=R(K)*C+YR(K)
   14 CONTINUE
   11 CONTINUE
      IF(NN.EQ.0)GO TO 8
      DO 62  K=1,NN
      M=K+1
      T1=T(M,1)
      T2=T(K,1)
      S1=S(M,1)
      S2=S(K,1)
      IF(K.EQ.NN)S1=S(1,1)
      IF(K.EQ.NN)T1=T(1,1)
      IF(RR(K))63,64,63
   64 DELT=T1-T2
      DELS=S1-S2
      B=ATAN2(DELT,DELS)
      DS=DELS/10.
      DT=DELT/10.
      DO 65  J=2,10
      A=J-1
      S(K,J)=S(K,1)+A*DS
   65 T(K,J)=T(K,1)+A*DT
      GO TO 62
   63 DRS=S(K,1)-SR(K)
      IF(DRS.EQ.0.)DRS=S(M,1)-SR(K)
      KOMP=0
      STHETA(K,1)=ATAN2((T2-TR(K)),(S2-SR(K)))
      STHETA(M,1)=ATAN2((T1-TR(K)),(S1-SR(K)))
      IF(DRS.LT.0.)KOMP=1
      IF(DRS.GT.0.)KOMP=1
      IF(KOMP.EQ.1)STHETA(K,1)=STHETA(K,1)-3.14159
      IF(KOMP.EQ.1)STHETA(M,1)=STHETA(M,1)-3.14159
      IF(STHETA(K,1).LT.0.)STHETA(K,1)=STHETA(K,1)+6.28318
      IF(STHETA(M,1).LT.0.)STHETA(M,1)=STHETA(M,1)+6.28318
      IF(STHETA(K,1).GT.3.14159.AND.STHETA(M,1).EQ.0.)STHETA(M,1)=
     16.28318
      DT=(STHETA(M,1)-STHETA(K,1))/10.
      DO 79  J=2,10
      A=J-1
      STHETA(K,J)=STHETA(K,1)+A*DT
      PP=STHETA(K,J)
      IF(KOMP.EQ.1)PP=PP+3.14159
```

```
      B=COS(PP)
      C=SIN(PP)
      S(K,J)=RR(K)*B+SR(K)
   79 T(K,J)=RR(K)*C+TR(K)
   62 CONTINUE
    8 BETAN=2.*3.14159/SEGN
      DB=BETAN/200.
      SUFX=0.
      SUFY=0.
      SUMMX=0.
      SUMMY=0.
      SCGMY=0.
      SCGMX=0.
      SUMWT=0.
      SB=SIN(DB)
      IF(KPRINT.EQ.1.OR.KPRINT.EQ.2)GO TO 6
      PRINT 53
   53 FORMAT(1H1,10X,1HX,14X,1HY,12X,5HXCENT,10X,5HYCENT,9X,5HTHETA,
     117X,4HAREA,8X,5HPRESS)
    6 DO 43 K=1,N
      DO 43 J=1,10
      M=J+1
      L=K+1
      Y1=Y(K,J)
      Y2=Y(K,M)
      X1=X(K,J)
      X2=X(K,M)
      IF(J.EQ.10.AND.K.NE.N)Y2=Y(L,1)
      IF(J.EQ.10.AND.K.NE.N)X2=X(L,1)
      IF(J.EQ.10.AND.K.EQ.N)Y2=YEND
      IF(J.EQ.10.AND.K.EQ.N)X2=XEND
      W1=2.*Y1*SB
      W2=2.*Y2*SB
      YDIF=ABS(Y1-Y2)
      XDIF=ABS(X1-X2)
      HS=ABS((YDIF**2.)+(XDIF**2.))
      H=SQRT(HS)
      AREA=(W1+W2)*H/2.
      IF(W1-W2) 21,22,23
   21 XCENT=(X2-X1)*(W1+2.*W2)/(3.*(W1+W2))+X1
      YCENT=(Y2-Y1)*(W1+2.*W2)/(3.*(W1+W2))+Y1
      GO TO 17
   22 IF(X1.GT.X2)X3=X2
      IF(X1.LT.X2)X3=X1
      X4=ABS(X1-X2)
      XCENT=X3+X4/2.
      YCENT=Y(K,1)
      GO TO 17
   17 CONTINUE
   23 XCENT=(X1-X2)*(W2+2.*W1)/(3.*(W1+W2))+X2
      YCENT=(Y1-Y2)*(W2+2.*W1)/(3.*(W1+W2))+Y2
      LPK=LP(K)
      GO TO (28,29,33)LPK
   28 PS=P(K)
      GO TO 32
   29 P1=P(K)
      P2=P(L)
```

```
      X1=X(K,1)
      X2=X(L,1)
      IF(K.EQ.N)X2=XEND
      Y1=Y(K,1)
      Y2=Y(L,1)
      IF(K.EQ.N)Y2=YEND
      S1=X2-X1
      S2=Y2-Y1
      S3=S1
      IF(S1.EQ.0.)S3=S2
      SLO=(P2-P1)/S3
      DX1=(X(K,J)-X(K,1))
      DY1=(Y(K,J)-Y(K,1))
      DS=DX1
      IF(DX1.EQ.0.)DS=DY1
      PS=SLO*DS+P1
      GO TO 32
   33 CALL PRESS(X,Y,PS)
   32 CONTINUE
      FX=AREA*PS*COS(THETA(K,J))
      FY=AREA*PS*SIN(THETA(K,J))
      SUFX=SUFX+FX
      SUFY=SUFY+FY
      XMOM=FY*(XLEG-XCENT)
      YMOM=FX*(YCENT-YLEG)
      SUMMX=SUMMX+XMOM
      SUMMY=SUMMY+YMOM
      IF(KPRINT.EQ.1.OR.KPRINT.EQ.2)GO TO 44
      DATA(1)=X(K,J)
      DATA(2)=Y(K,J)
      DATA(3)=XCENT
      DATA(4)=YCENT
      DATA(5)=THETA(K,J)*(180./3.14159)
      DATA(6)=AREA
      DATA(7)=PS
      WRITE(6,42)K,J,(DATA(L),L=1,7)
   42 FORMAT(1H ,2I2,4F15.5,F13.2,1F12.4,1F16.3)
   44 B=COS(THETA(K,J))
      WT=RHO(K)*AREA*ABS(B)*XCENT
      SUMWT=SUMWT+WT
      CGMX=WT*(XCENT/2.)
      SCGMX=SCGMX+CGMX
      CGMY=WT*(YCENT)
   43 SCGMY=SCGMY+CGMY
      BB=BETAR/2.
      IF(NN.EQ.0)GO TO 7
      ASUM=0.
      ASSUM=0.
      PRINT 66
   66 FORMAT(1H1,14X,1HS,15X,1HT,15X,4HAREA,12X,4HAMOM,12X,4HACUM)
      DO 67  K=1,NN
      DO 67  J=1,10
      ICE=0
      L=K+1
      M=J+1
      IF(J.EQ.10.AND.K.NE.NN)ICE=1
      IF(ICE.EQ.1)S(K,M)=S(L,1)
```

```
      IF(ICE.EQ.1)T(K,M)=T(L,1)
      IF(J.EQ.10.AND.K.EQ.NN)ICE=2
      IF(ICE.EQ.2)S(K,M)=S(1,1)
      IF(ICE.EQ.2)T(K,M)=T(1,1)
      AREA=-.5*(S(K,J)+S(K,M))*(T(K,M)-T(K,J))
      ASUM=ASUM+AREA
      ADS=AREA*.25*(S(K,J)+S(K,M))
      ASSUM=ASSUM+ADS
      DATA(1)=S(K,J)
      DATA(2)=T(K,J)
      DATA(3)=AREA
      DATA(4)=ADS
      DATA(5)=ASUM
   67 WRITE(6,68)K,J,(DATA(L),L=1,5)
   68 FORMAT(2I2,5F16.4)
      SCENT=ASSUM/ASUM
      FANF=PRE*ASUM
      FMS=2.*FANF*SIN(BB)
      SMOM=FMS*(XLEG-SCENT)
      IF(KPRINT.EQ.2)GO TO 7
      PRINT 69
   69 FORMAT(*1PRESSURIZED SABOT INTERFACE CONFIGURATION*)
      PRINT 70
   70 FORMAT(*      S       T       RR       SR       TR*)
      DO 71  I=1,NN
      DATA(1)=S(I,1)
      DATA(2)=T(I,1)
      DATA(3)=RR(I)
      DATA(4)=SR(I)
      DATA(5)=TR(I)
   71 WRITE(6,72)(DATA(L),L=1,5)
   72 FORMAT(1X ,5F8.4)
    7 IF(SUMWT.EQ.0)GO TO 480
      CGX=SCGMX/SUMWT
      CGY=SCGMY/SUMWT
  480 TWT=SUMWT*100.
      ATOT=((DIA/25.4)**2.)*0.7854
      PRJWT=(SEGN*TWT+WTR)
      STB=PRE*ATOT/PRJWT
   45 SBF=(0.-STB)*SUMWT
      SBFMOM=SBF*(CGY-YLEG)
      SPRAD=SPIN*2.*3.14159
      SPINF=SUMWT*(SPRAD**2.)*CGY/(32.18*12.)
      SPMOM=SPINF*(XLEG-CGX)
      YVAR=0.
      B=(0.-BETAR)/2.
      YV=1.
      DO 130 K=1,100
      YVAR=YVAR+YV*COS(B)
  130 B=B+DB*2.
      TSUFX=100.*SUFX
      IF(NN.EQ.0)FMS=0.
      TSUFY=YVAR*SUFY
      TSBF=100.*SBF
      TSPINF=YVAR*SPINF
      XFORCE=TSUFX+TSBF
      YFORCE=TSUFY+TSPINF
```

```
      TCGY=YVAR*CGY/100.
      IF(NN.EQ.0)SMOM=0.
      TXMOM=YVAR*SUMX
      IF(SUFX.EQ.0.)GO TO 569
      YMOMC=SUMMY/SUFX+YLEG
      TYMOMC=(YVAR/100.)*YMOMC-YLEG
      TYMOM=TYMOMC*TSUFX
  569 CONTINUE
      IF(SBF.EQ.0.)GO TO 570
      SBMOMC=SBFMOM/SBF+YLEG
      TSBMC=YVAR*SBMOMC-YLEG
      TSBMOM=TSBMC*SBF
  570 CONTINUE
      BETA=360./SEGN
      TSPMOM=YVAR*SPMOM
      IF(KPRINT.EQ.2)GO TO 5
      PRINT 704
  704 FORMAT(*1SABOT CONFIGURATION*/
     1*     X          Y          R          XR          YR        DENSITY*)
      DO 705 I=1,N
      DATA(1)=X(I,1)
      DATA(2)=Y(I,1)
      DATA(3)=R(I)
      DATA(4)=XR(I)
      DATA(5)=YR(I)
      DATA(6)=RHO(I)
  705 WRITE(6,706)(DATA(L),L=1,6)
  706 FORMAT(1H ,6F8.4)
      WRITE(6,707)XLEG,YLEG,XEND,YEND
  707 FORMAT(* X MOM CENT Y MOM CENT X END POINT Y END POINT*/
     1,1H ,4F11.4)
      PRINT 708
  708 FORMAT(*0PRESSURE VALUES*//*   PRESS   CODE*)
      DO 709 K=1,N
  709 WRITE(6,710)K,P(K),LP(K)
  710 FORMAT(1H ,I2,3F10.2,3H   ,I1)
    5 WRITE(6,10)TYPE
   10 FORMAT(1H1,6A10)
      IBETA=BETA
      WRITE(6,114)IBETA
  114 FORMAT(*0VALUES FOR *,I3,* DEGREE SEGMENT*)
      CTRX=TYMOMC+YLEG
      WRITE(6,115)TSUFX,CTRX
  115 FORMAT(*0PRESSURE FORCE IN X DIRECTION = *,F15.4,* LBS, CENTROID =
     1*,F6.3,* IN*)
      IF(TSUFY.NE.0.)GO TO 910
      XMOMC=0.
      GO TO 911
  910 XMOMC=XLEG-SUMMX/SUFY
  911 WRITE(6,912)TSUFY,XMOMC
  912 FORMAT(* PRESSURE FORCE IN Y DIRECTION(EXCLUSIVE OF INTERFACE PRES
     1S)= *,F15.4,*LBS, CENTROID= *,F6.3,*INCHES*)
      WRITE(6,74)FANF
   74 FORMAT(* NORMAL PRESSURE FORCE ON ONE INTERFACE= *,F8.2,*LB*)
      WRITE(6,9)PRE
    9 FORMAT(* PRESSURE = *,F10.2)
      WRITE(6,913)STH,TSHF
```

```
913 FORMAT(*0SETBACK = *,F15.4,* GEES  SETBACK FORCE = *,
   1F15.4,* LBS*)
    WRITE(6,481)SPIN,TSPINF
481 FORMAT(*0SPIN = *,F6.2,* RPS, SPIN FORCE = *,F15.4,
   1* LBS*)
    WRITE(6,75)FMS
 75 FORMAT(* OVERTURNING MOMENT FORCE ON ONE SEGMENT DUE TO PRESSURIZE
   1D INTERFACE= *,F8.2,*LB*)
    WRITE(6,73)ASUM
 73 FORMAT(* AREA OF PRESSURIZED INTERFACE= *,F8.4,*SQ.IN.*)
    WRITE(6,77)SCENT
 77 FORMAT(* CENTROID OF INTERFACE IN AXIAL DIRECTION= *,F8.4,*IN.*)
    WRITE(6,120)XLEG,YLEG
120 FORMAT(*0    MOMENTS ABOUT X = *,F6.3,* Y = *,F6.3)
    WRITE(6,123)TYMOM
123 FORMAT(*0MOMENT DUE TO PRESSURE IN AXIAL DIRECTION = *
   1,F15.4,* INCH LBS*)
    WRITE(6,124)TXMOM
124 FORMAT(* MOMENT DUE TO PRESSURE IN RADIAL DIRECTION = *
   1,F15.4,*INCH LBS*)
    WRITE(6,125)TSBMOM
125 FORMAT(* MOMENT DUE TO SETBACK FORCE = *,F15.4,* INCH LBS*)
    WRITE(6,76)SMOM
 76 FORMAT(* MOMENT DUE TO PRESSURE ON INTERFACE = *,F12.4
   1,*INCH LBS*)
    WRITE(6,126)TSPMOM
126 FORMAT(* MOMENT DUE TO SPIN FORCE = *,F15.4,* INCH LBS*)
    TMO=TXMOM+TYMOM+TSBMOM+TSPMOM+SMOM
    TMOABS=ABS(TMO)
    TMBIG=TMO*100.
    TRUTH=AINT(TMBIG)
    IF(TRUTH)134,135,136
134 WRITE(6,137)TMOABS
137 FORMAT(*0TOTAL MOMENT = *,F15.4,* INCH LBS COUNTERCLOCKWISE*)
    GO TO 140
135 WRITE(6,138)TMOABS
138 FORMAT(*0TOTAL MOMENT = *,F15.4,* INCH LBS NEUTRAL*)
    GO TO 140
136 WRITE(6,139)TMOABS
139 FORMAT(*0TOTAL MOMENT = *,F15.4,* INCH LBS CLOCKWISE*)
140 PRINT 133
133 FORMAT(*0PHYSICAL CHARACTERISTICS*)
    WRITE(6,121)CGX,TCGY
121 FORMAT(*0CENTER OF GRAVITY OF SEGMENT AT X= *,F6.3,*Y= *,F6.3)
    WRITE(6,142)TWT,WTP,PRJWT
142 FORMAT(*0WEIGHT SUMMARY*/* SEGMENT WEIGHT = *,F10.4,
   1* LBS, SUB-PROJ WEIGHT = *,F10.4,* LBS, PROJECTILE WEIGHT = *
   2,F10.4,* LBS*)
    KRUN=KRUN+1
    IF(KRUN.NE.NRUN)GO TO 41
    L=0
    DO 78  K=1,N
    DO 78  J=1,10
    L=L+1
    XT(L)=X(K,J)
 78 YT(L)=Y(K,J)
    XT(NJAY)=X(1,1)
```

```
PROGRAM NORM       74/74    OPT=1                    FTN 4.1+PSR367     01/28/75  08.40.48.      PAGE     8

              YT(NJAY)=Y(1,1)
              IF(NN)19,16,19
           19 L=0
              DO 15    K=1,NN
              DO 15    J=1,10
              L=L+1
              ST(L)=S(K,J)
           15 TT(L)=T(K,J)
              ST(NNJAY)=S(1,1)
              TT(NNJAY)=T(1,1)
           16 CALL NANCYL(10HAXIS DISPL,5H(IN.),6HRADIAL,5H(IN.),1)
              CALL NANCYT(10HMOMENTS ON,8H SEGMENT)
              CALL NANCYS(19HSABOT CROSS SECTION)
              IF(NN.NE.0)GO TO 25
              CALL NANCY(XT,YT,NJAY,12.,0.,8.,0.,2,3)
              GO TO 24
           25 CALL NANCY2(ST,TT,NNJAY,XT,YT,NJAY,12.,0.,8.,0.,2,3)
           24 STOP
              END
```

REFERENCES

1. I.E. Rucker, Instructions for Using IBM 709 Plotting Subroutines, April 1964.

2. Glen Randers-Pehrson, "NANCY" A Digital Plotting Routine, Picatinny Arsenal Technical Memorandum ESD IR 468, August 1971.

3. I. E. Rucker, Plotting Routines, Picatinny Arsenal Information Report NR 73-6, February 1973.

APPENDIX

SAMPLE CASE

The following example should give the user a good idea of input format and the usual output from this program.

This sample case is illustrated by a drawing of the cabot section (Fig 2) with points of inflection shown. This is followed by coding sheets (Fig 3) for its input and a listing of all its output (Fig 4). Finally, the NANCY printer plot (Fig 5) and CALCOMP digital plot (Fig 6) are included as they would appear as part of the complete data printout.

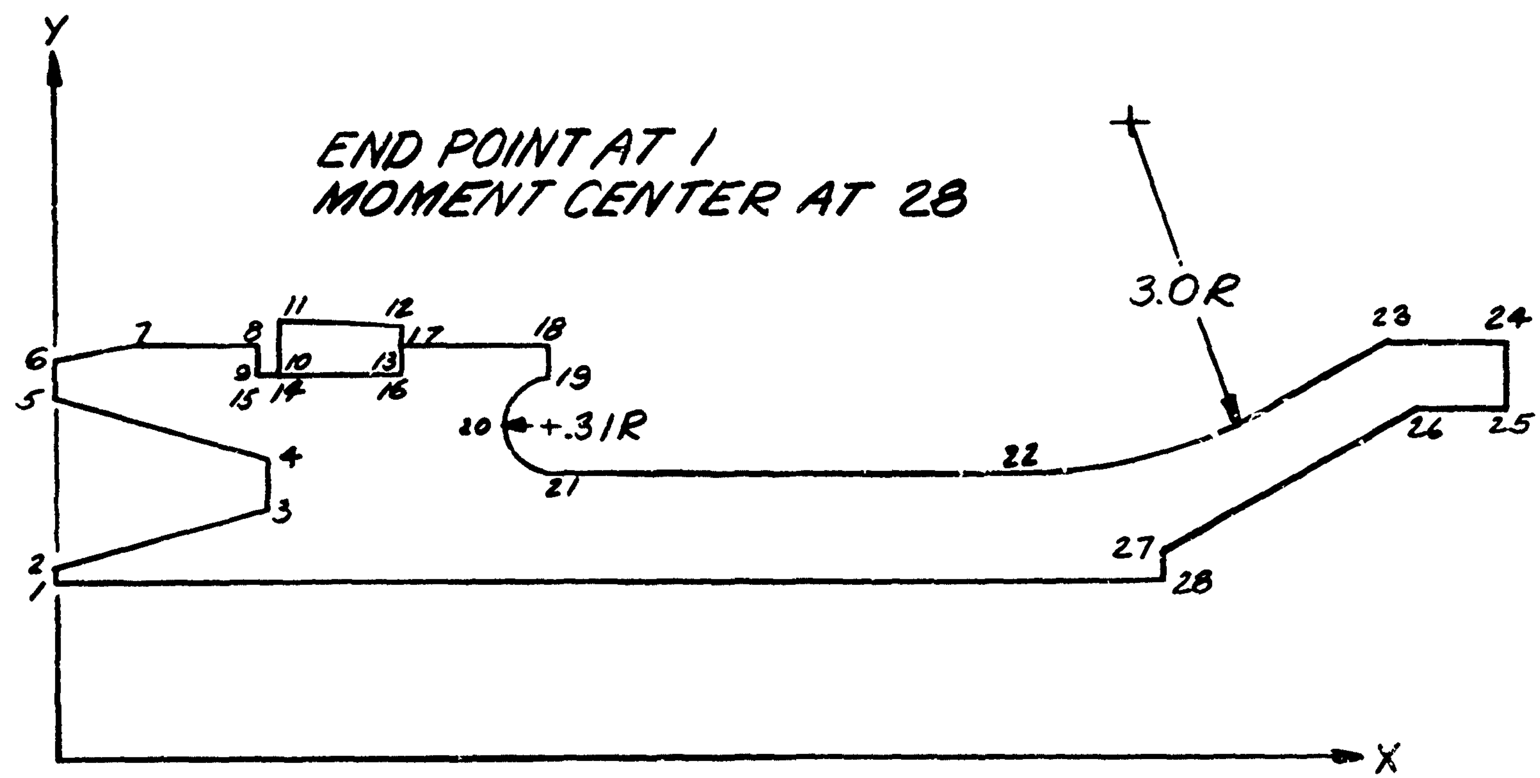

Fig 2 Sabot Cross Section

NORM.								
COMMENT. 1. AR.								
ATTACK, X, SREOT, CY=3.								
X.								
1/0/1								
428.05								4 RUNS
0.	.667	0.	0.	0.	-.101	1.	1	28 CARDS DESCRIBING
0.	.837	0.	0.	0.	-.101	1.	1	GEOMETRY
1.007	1.015	0.	0.	0.	-.101	1.	1	
1.007	1.42	0.	0.	0.	-.101	1.	1	
0.	1.68	0.	0.	0.	-.101	1.	1	
0.	1.97	0.	0.	0.	-.101	1.	1	
.622	2.05	0.	0.	0.	-.101	1.	1	
.97	2.05	0.	0.	0.	.101	1.	1	
.97	1.876	0.	0.	0.	0.	1.	1	
1.	1.876	0.	0.	0.	-.047	0.	1	
1.	2.1	0.	0.	0.	-.047	0.	1	
1.735	0.	0.	0.	0.	.047	0.	1	
1.735	1.876	0.	0.	0.	.047	0.	1	

Fig 3 Input data cards format

1.	1.876	0.	0.	0.	0.	0.	1
.97	1.876	0.	0.	0.	.101	1.	2
1.735	1.876	0.	0.	0.	.101	0.	1
1.735	2.05	0.	0.	0.	.101	0.	1
2.378	2.05	0.	0.	0.	.101	0.	1
2.378	1.9	.31	2.378	1.59	.101	0.	1
2.068	1.59	.31	2.378	1.59	.101	0.	1
2.378	1.28	0.	0.	0.	.101	0.	1
5.7	1.28	3.	5.7	4.28	.101	0.	1
7.574	2.05	0.	0.	0.	.101	0.	1.
8.224	2.05	0.	0.	0.	.101	0.	1
8.324	1.65	0.	0.	0.	.101	0.	1
7.78	1.65	0.	0.	0.	.101	0.	1
6.285	.901	0.	0.	0.	.101	0.	1
6.285	.667	0.	0.	0.	.101	0.	1
0.	1.659	0.	0.	0.			
.622	2.05	0.	0.	0.			
.95	2.05	0.	0.	0.			
.95	1.458	0.	0.	0.			
6.285	.667	0.	.667				

5 CARDS DESCRIBING PRESSURIZED PLANAR SURFACE GEOMETRY

Fig 3 (Continued)

```
6.285   .667 0.        .667                                              } 1ST RUN
3.60000.1.05.8.1 0.    SABOT TEST FOR MOMENT ABOUT AFT EDGE              }

0.      .667 0.        .667                                              } 2nd RUN
3.10000.1.05.8.1 100.2 SABOT TEST FOR MOMENT ABOUT FIRST TOOTH           }

6.285   .667 0.        .667                                              } 3RD RUN
4.60000.1.05.8.1 0.002 SABOT TEST FOR MOMENT ABOUT AFT EDGE              }

0.      .667 0.        .667                                              } 4th RUN
4.10000.1.05.8.1 100.2 SABOT TEST FOR MOMENT ABOUT FIRST TOOTH           }
6/7/8/9
```

Fig 3 (Continued)

```
SABOT TEST FOR MOMENT ABOUT FRT EDGE

VALUES FOR 120 DEGREE SEGMENT

PRESSURE FORCE IN X DIRECTION =      193172.3839 LBS, CENTROID = 1.131 IN
PRESSURE FORCE IN Y DIRECTION(EXCLUSIVE OF INTERFACE PRESS)=    -225791.6032LBS, CENTROID=   .787INCHES
NORMAL PRESSURE FORCE ON ONE INTERFACE= 25753.20LB
PRESSURE =   60000.00

SETBACK =      59857.3701 GEES  SETBACK FORCE =    -106815.7227 LBS

SPIN =   0.00 RPS, SPIN FORCE =           0.0000 LBS
OVERTURNING MOMENT FORCE ON ONE SEGMENT DUE TO PRESSURIZED INTERFACE= 44605.83LB
AREA OF PRESSURIZED INTERFACE=    .4292SQ.IN.
CENTROID OF INTERFACE IN AXIAL DIRECTION=    .5314IN.

     MOMENTS ABOUT X =  6.285 Y =  .667

MOMENT DUE TO PRESSURE IN AXIAL DIRECTION =        89575.1637 INCH LBS
MOMENT DUE TO PRESSURE IN RADIAL DIRECTION =   -1241441.7563INCH LBS
MOMENT DUE TO SETBACK FORCE =    -124752.2522 INCH LBS
MOMENT DUE TO PRESSURE ON INTERFACE =  256644.0914INCH LBS
MOMENT DUE TO SPIN FORCE =            0.0000 INCH LBS

TOTAL MOMENT =    1019974.7534 INCH LBS COUNTERCLOCKWISE

PHYSICAL CHARACTERISTICS

CENTER OF GRAVITY OF SEGMENT AT X=  3.506Y=  1.175

WEIGHT SUMMARY
SEGMENT WEIGHT =    1.7845 LBS, SUB-PROJ WEIGHT =    8.1000 LBS, PROJECTILE WEIGHT =   13.4535 LBS
```

Fig 4   Computer output

```
SABOT TEST FOR MOMENT ABOUT FIRST TOOTH

VALUES FOR 120 DEGREE SEGMENT

PRESSURE FORCE IN X DIRECTION =      32195.3973 LBS, CENTROID = 1.131 IN
PRESSURE FORCE IN Y DIRECTION(EXCLUSIVE OF INTERFACE PRESS)=     -37631.9339LBS, CENTROID=   .787INCHES
NORMAL PRESSURE FORCE ON ONE INTERFACE=  4292.20LB
PRESSURE =   10009.00

SETBACK =        9976.2283 GEES   SETBACK FORCE =      -17802.6204 LBS

SPIN = 100.00 RPS, SPIN FORCE =        2142.8693 LBS
OVERTURNING MOMENT FORCE ON ONE SEGMENT DUE TO PRESSURIZED INTERFACE=  7434.30LB
AREA OF PRESSURIZED INTERFACE=     .429250.IN.
CENTROID OF INTERFACE IN AXIAL DIRECTION=     .5314IN.

    MOMENTS ABOUT X =  0.000 Y =  .667

MOMENT DUE TO PRESSURE IN AXIAL DIRECTION =       14929.1939 INCH LBS
MOMENT DUE TO PRESSURE IN RADIAL DIRECTION =       29609.7450INCH LBS
MOMENT DUE TO SETBACK FORCE =      -20792.0420 INCH LBS
MOMENT DUE TO PRESSURE ON INTERFACE =    -3950.5897INCH LBS
MOMENT DUE TO SPIN FORCE =      -7513.8534 INCH LBS

TOTAL MOMENT =      12282.4538 INCH LBS CLOCKWISE

PHYSICAL CHARACTERISTICS

CENTER OF GRAVITY OF SEGMENT AT X=  3.506Y=  1.175

WEIGHT SUMMARY
SEGMENT WEIGHT =      1.7845 LBS, SUB-PROJ WEIGHT =      8.1000 LBS, PROJECTILE WEIGHT =    13.4535 LBS
```

Fig 4 (Continued)

```
SABOT TEST FOR MOMENT ABOUT FIRST TOOTH

VALUES FOR  90 DEGREE SEGMENT

PRESSURE FORCE IN X DIRECTION =       24146.7411 LBS, CENTROID = 1.231 IN
PRESSURE FORCE IN Y DIRECTION(EXCLUSIVE OF INTERFACE PRESS)=     -30727.0778LBS, CENTROID=   .787INCHES
NORMAL PRESSURE FORCE ON ONE INTERFACE=  4292.20LB
PRESSURE =   10000.00

SETBACK =        9976.1966 GEES  SETBACK FORCE =     -13352.0296 LBS

SPIN = 100.00 RPS, SPIN FORCE =        1749.6872 LBS
OVERTURNING MOMENT FORCE ON ONE SEGMENT DUE TO PRESSURIZED INTERFACE=  6070.08LB
AREA OF PRESSURIZED INTERFACE=    .4292SQ.IN.
CENTROID OF INTERFACE IN AXIAL DIRECTION=    .5314IN.

    MOMENTS ABOUT X =  0.000 Y =   .667

MOMENT DUE TO PRESSURE IN AXIAL DIRECTION =       13618.1851 INCH LBS
MOMENT DUE TO PRESSURE IN RADIAL DIRECTION =       24176.8318INCH LBS
MOMENT DUE TO SETBACK FORCE =      -16984.8795 INCH LBS
MOMENT DUE TO PRESSURE ON INTERFACE =   -3225.6425INCH LBS
MOMENT DUE TO SPIN FORCE =      -6135.1819 INCH LBS

TOTAL MOMENT =       11449.3131 INCH LBS CLOCKWISE

PHYSICAL CHARACTERISTICS

CENTER OF GRAVITY OF SEGMENT AT X=  3.506Y=  1.279

WEIGHT SUMMARY
SEGMENT WEIGHT =     1.3384 LBS, SUB-PROJ WEIGHT =     8.1000 LBS, PROJECTILE WEIGHT =    13.4536 LBS
```

Fig 4   (Continued)

```
SABOT TEST FOR MOMENT ABOUT FRT EDGE

VALUES FOR  90 DEGREE SEGMENT

PRESSURE FORCE IN X DIRECTION =      144880.4464 LBS, CENTROID = 1.231 IN
PRESSURE FORCE IN Y DIRECTION(EXCLUSIVE OF INTERFACE PRESS)=    -184362.4665LBS, CENTROID=   .787INCHES
NORMAL PRESSURE FORCE ON ONE INTERFACE= 25753.20LB
PRESSURE =   60000.00

SETBACK =       59857.1796 GEES  SETBACK FORCE =     -80112.1777 LBS

SPIN =   0.00 RPS, SPIN FORCE =            0.0000 LBS
OVERTURNING MOMENT FORCE ON ONE SEGMENT DUE TO PRESSURIZED INTERFACE= 36420.50LB
AREA OF PRESSURIZED INTERFACE=    .4292SQ.IN.
CENTROID OF INTERFACE IN AXIAL DIRECTION=    .5314IN.

    MOMENTS ABOUT X =  6.285 Y =   .667

MOMENT DUE TO PRESSURE IN AXIAL DIRECTION =       81709.1104 INCH LBS
MOMENT DUE TO PRESSURE IN RADIAL DIRECTION =   -1013657.1112INCH LBS
MOMENT DUE TO SETBACK FORCE =    -101909.2770 INCH LBS
MOMENT DUE TO PRESSURE ON INTERFACE =  209548.9912INCH LBS
MOMENT DUE TO SPIN FORCE =           0.0000 INCH LBS

TOTAL MOMENT =      824308.2867 INCH LBS COUNTERCLOCKWISE

PHYSICAL CHARACTERISTICS

CENTER OF GRAVITY OF SEGMENT AT X=  3.506Y=  1.279

WEIGHT SUMMARY
SEGMENT WEIGHT =     1.3384 LBS, SUB-PROJ WEIGHT =     8.1000 LBS, PROJECTILE WEIGHT =    13.4536 LBS
```

Fig 4   (Continued)

SABOT CONFIGURATION

X	Y	R	XR	YR	DENSITY
0.0000	.6670	0.0000	0.0000	0.0000	-.1010
0.0000	.8290	0.0000	0.0000	0.0000	-.1010
1.0070	1.0150	0.0000	0.0000	0.0000	-.1010
1.0070	1.4200	0.0000	0.0000	0.0000	-.1010
0.0000	1.6880	0.0000	0.0000	0.0000	-.1010
0.0000	1.9700	0.0000	0.0000	0.0000	-.1010
.6220	2.0500	0.0000	0.0000	0.0000	-.1010
.9700	2.0500	0.0000	0.0000	0.0000	.1010
.9700	1.8760	0.0000	0.0000	0.0000	0.0000
1.0000	1.8760	0.0000	0.0000	0.0000	-.0470
1.0000	2.1000	0.0000	0.0000	0.0000	-.0470
1.7350	2.1000	0.0000	0.0000	0.0000	.0470
1.7350	1.8760	0.0000	0.0000	0.0000	.0470
1.0000	1.8760	0.0000	0.0000	0.0000	0.0000
.9700	1.8760	0.0000	0.0000	0.0000	.1010
1.7350	1.8760	0.0000	0.0000	0.0000	-.1010
1.7350	2.0500	0.0000	0.0000	0.0000	.1010
2.3780	2.0500	0.0000	0.0000	0.0000	.1010
2.3780	1.9000	.3100	2.3780	1.5900	.1010
2.0680	1.5900	.3100	2.3780	1.5900	.1010
2.3780	1.2800	0.0000	0.0000	0.0000	.1010
5.7000	1.2800	3.0000	5.7000	4.2800	-.1010
7.5740	2.0500	0.0000	0.0000	0.0000	.1010
8.3240	2.0500	0.0000	0.0000	0.0000	.1010
8.3240	1.6500	0.0000	0.0000	0.000	.1010
7.7800	1.6500	0.0000	0.0000	0.0000	.1010
6.2850	.8010	0.0000	0.0000	0.0000	.1010
6.2850	.6670	0.0000	0.0000	0.000	.1010

X MOM CENT	Y MOM CENT	X END POINT	Y END POINT
6.2850	.6670	0.0000	.6670

PRESSURE VALUES

	PRESS	CODE
1	60000.00	0.00
2	60000.00	0.00
3	60000.00	0.00
4	60000.00	0.00
5	60000.00	0.00
6	60000.00	0.00
7	60000.00	0.00
8	60000.00	0.00
9	60000.00	0.00
10	0.00	0.00
11	0.00	0.00
12	0.00	0.00
13	0.00	0.00
14	0.00	0.00
15	60000.00	0.00
16	0.00	0.00
17	0.00	0.00
18	0.00	0.00
19	0.00	0.00
20	0.00	0.00
21	0.00	0.00
22	0.00	0.00
23	0.00	0.00
24	0.00	0.00
25	0.00	0.00
26	0.00	0.00
27	0.00	0.00
28	0.00	0.00

Fig 4 (Continued)

	S	T	AREA	AMOM	ACUM
1 1	0.0000	1.6880	-0.0000	0.0000	0.0000
1 2	0.0000	1.7162	-0.0000	0.0000	0.0000
1 3	0.0000	1.7444	-0.0000	0.0000	0.0000
1 4	0.0000	1.7726	-0.0000	0.0000	0.0000
1 5	0.0000	1.8008	-0.0000	0.0000	0.0000
1 6	0.0000	1.8290	-0.0000	0.0000	0.0000
1 7	0.0000	1.8572	-0.0000	0.0000	0.0000
1 8	0.0000	1.8854	-0.0000	0.0000	0.0000
1 9	0.0000	1.9136	-0.0000	0.0000	0.0000
110	0.0000	1.9418	-0.0000	0.0000	0.0000
2 1	0.0000	1.9700	-.0002	-.0000	-.0002
2 2	.0622	1.9780	-.0007	-.0000	-.0010
2 3	.1244	1.9860	-.0012	-.0001	-.0022
2 4	.1866	1.9940	-.0017	-.0002	-.0040
2 5	.2488	2.0020	-.0022	-.0003	-.0062
2 6	.3110	2.0100	-.0027	-.0005	-.0090
2 7	.3732	2.0180	-.0032	-.0007	-.0122
2 8	.4354	2.0260	-.0037	-.0009	-.0159
2 9	.4976	2.0340	-.0042	-.0011	-.0202
210	.5598	2.0420	-.0047	-.0014	-.0249
3 1	.6220	2.0500	-0.0000	0.0000	-.0249
3 2	.6548	2.0500	-0.0000	0.0000	-.0249
3 3	.6876	2.0500	-0.0000	0.0000	-.0249
3 4	.7204	2.0500	-0.0000	0.0000	-.0249
3 5	.7532	2.0500	-0.0000	0.0000	-.0249
3 6	.7860	2.0500	-0.0000	0.0000	-.0249
3 7	.8188	2.0500	-0.0000	0.0000	-.0249
3 8	.8516	2.0500	-0.0000	0.0000	-.0249
3 9	.8844	2.0500	-0.0000	0.0000	-.0249
310	.9172	2.0500	-0.0000	0.0000	-.0249
4 1	.9500	2.0500	.0564	.0268	.0316
4 2	.9500	1.9906	.0564	.0268	.0880
4 3	.9500	1.9312	.0564	.0268	.1444
4 4	.9500	1.8718	.0564	.0268	.2008
4 5	.9500	1.8124	.0564	.0268	.2573
4 6	.9500	1.7530	.0564	.0268	.3137
4 7	.9500	1.6936	.0564	.0268	.3701
4 8	.9500	1.6342	.0564	.0268	.4266
4 9	.9500	1.5748	.0564	.0268	.4830
410	.9500	1.5154	.0564	.0268	.5394
5 1	.9500	1.4560	-.0209	-.0094	.5185
5 2	.8550	1.4792	-.0187	-.0076	.4997
5 3	.7600	1.5024	-.0165	-.0059	.4832
5 4	.6650	1.5256	-.0143	-.0044	.4689
5 5	.5700	1.5488	-.0121	-.0032	.4568
5 6	.4750	1.5720	-.0099	-.0021	.4469
5 7	.3800	1.5952	-.0077	-.0013	.4391
5 8	.2850	1.6184	-.0055	-.0007	.4336
5 9	.1900	1.6416	-.0033	-.0002	.4303
510	.0950	1.6648	-.0011	-.0000	.4292

Fig 4 (Continued)

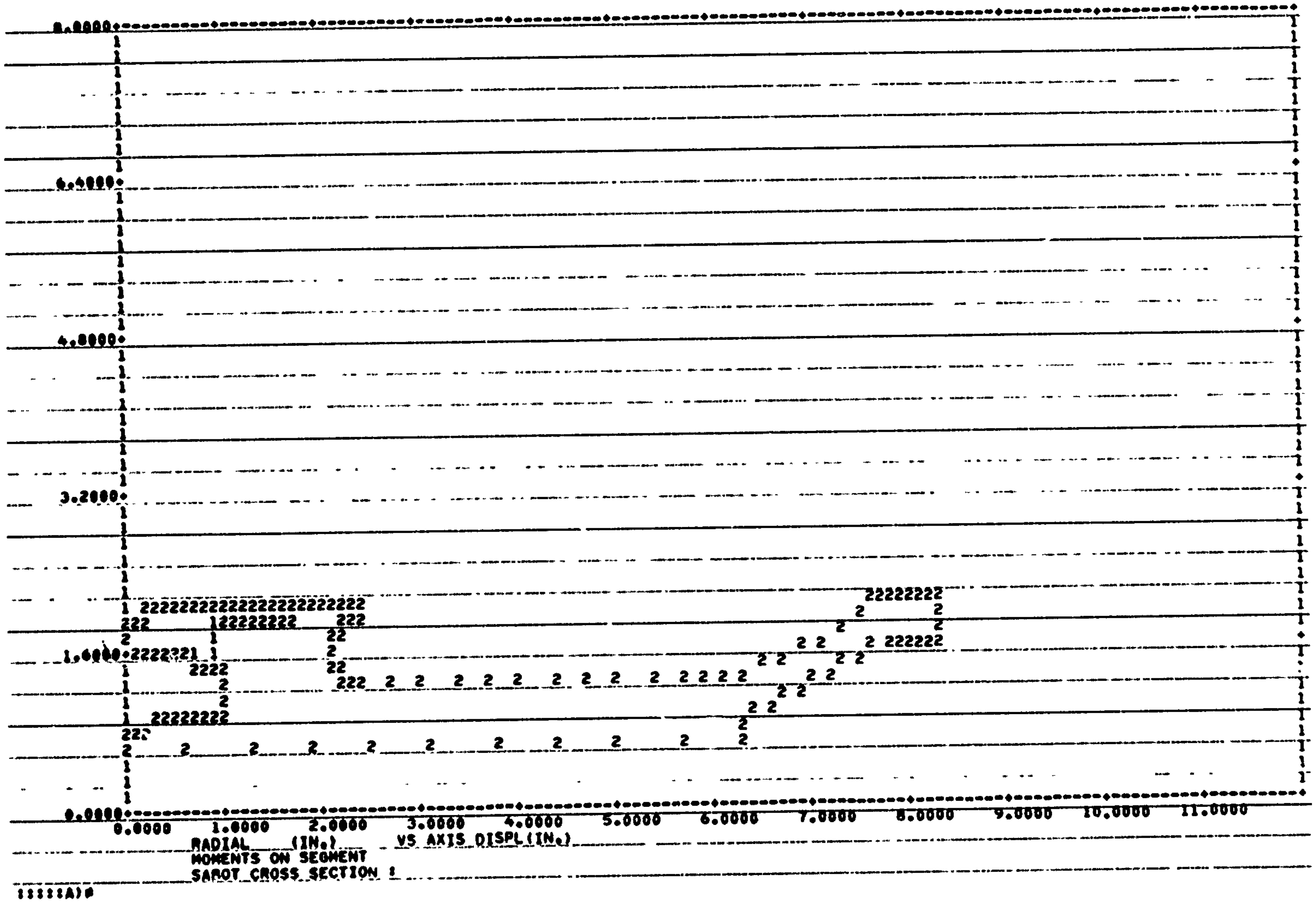

Fig 5 NANCY printer plot of sabot cross section

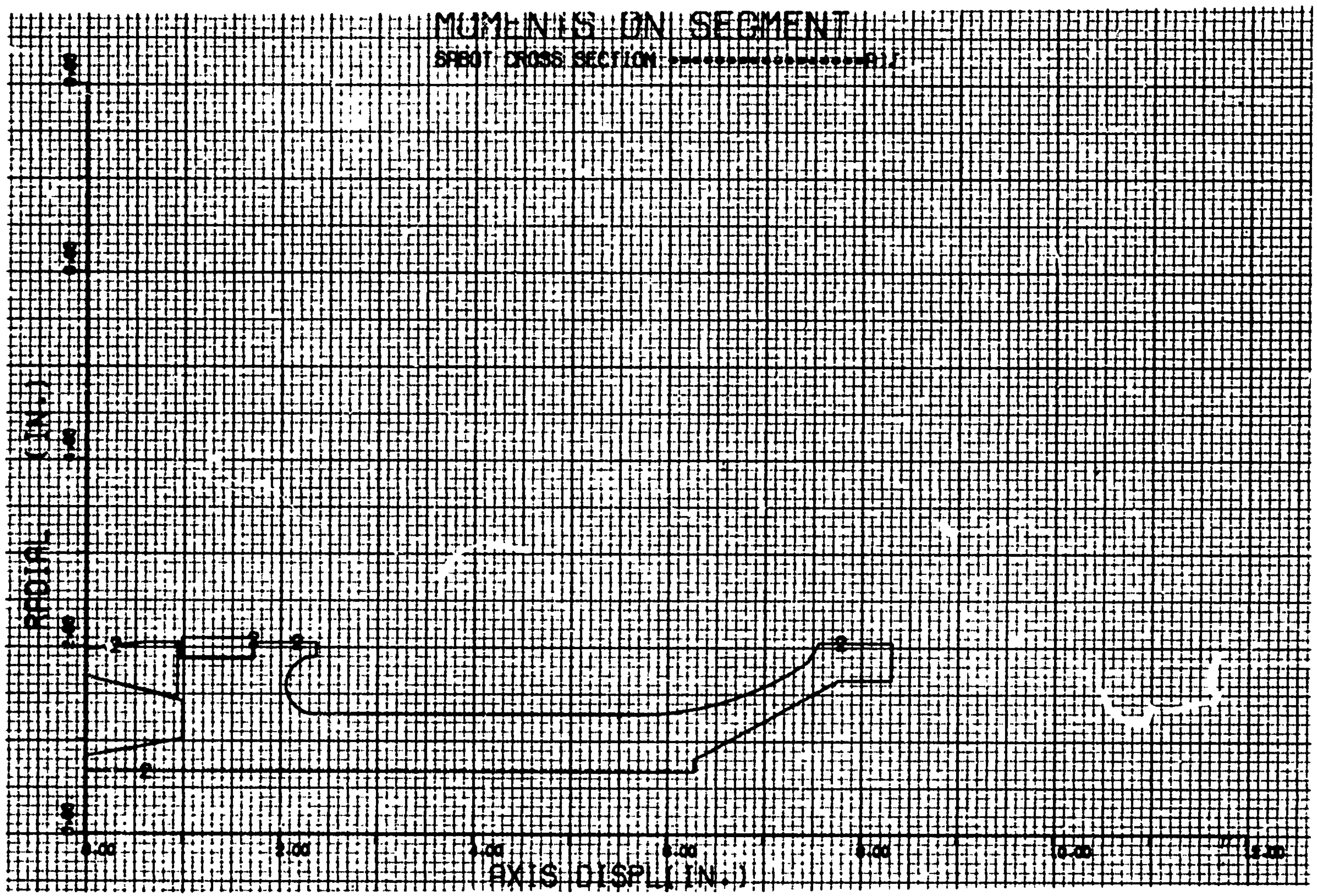

Fig 6 CALCOMP digital plot of sabot cross section